

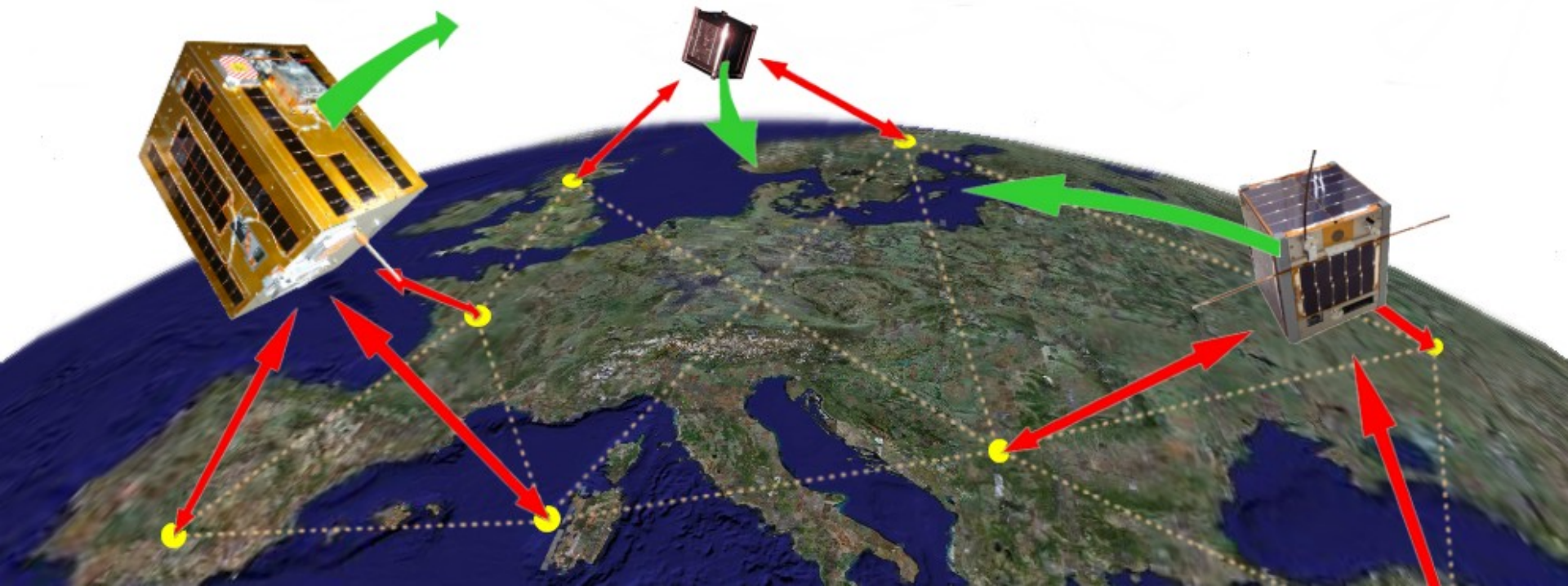


3- SSETI ESEO Project

4- The Future of the Amateur Satellite Service Spectrum



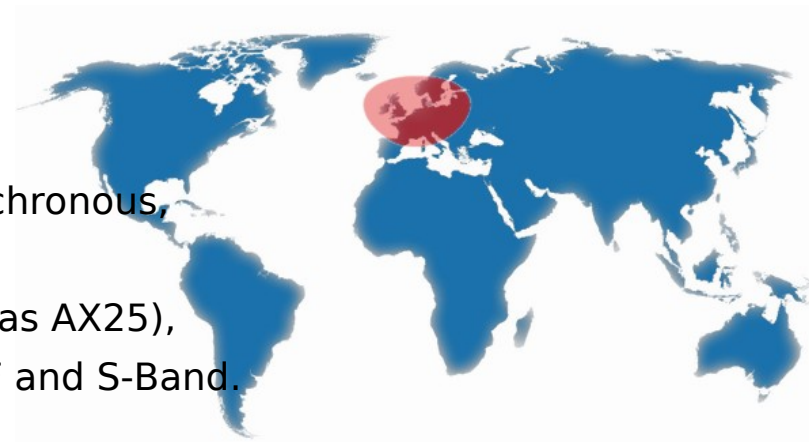
A Global Educational Network for Satellite Operations



The Current Situation

A Typical Student Space Segment

- Satellite in Low-Earth Orbit, often Sun Synchronous,
- Low-power transmitters,
- Standard communications protocols (such as AX25),
- Use of the Amateur Radio bands: VHF, UHF and S-Band.



A Typical Student Ground Segment

- A single, local, groundstation, usually at the host university,
- Capable of communication on one or two of the Amateur Radio frequency bands,
- A single rotator and a single elevator to track the spacecraft,
- A single PC controlling the groundstation hardware and the mission data.

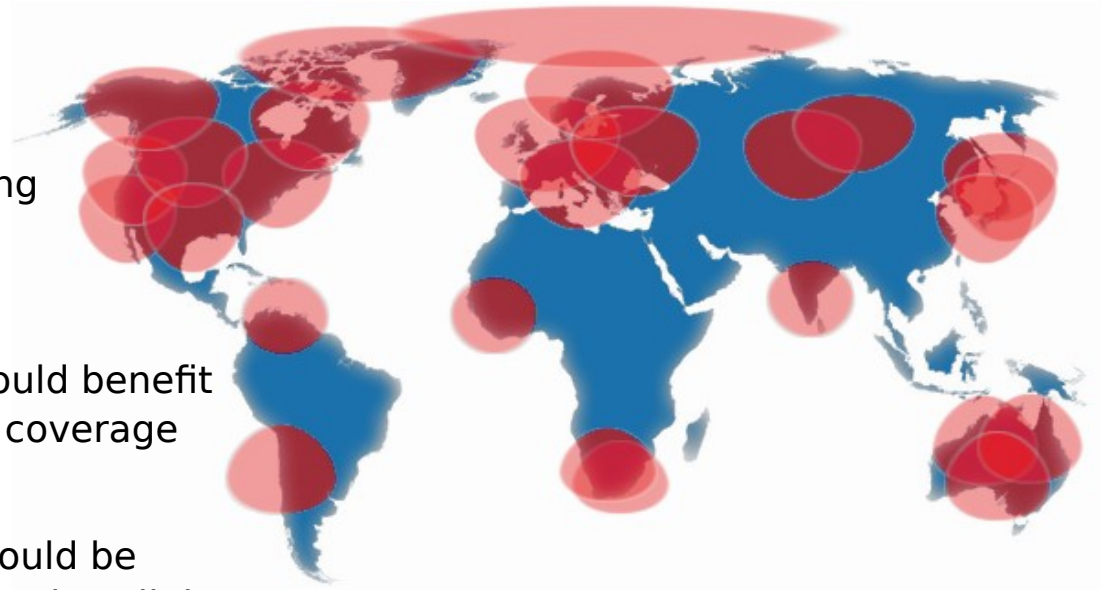
Typical Limitations

- From ~15 orbits there are around six passes a day, averaging perhaps five minutes each,
- Satellite is in communications range less than 3% of the mission time,
- For 97% of the time the groundstation is idle,
- The groundstation is not configured to communicate with other educational spacecraft,
- The spacecraft is only configured to communicate with the specific groundstation.

A Better Approach

Advantages of sharing resources

- Provides near-global coverage for all participating missions,
- Allows for a dramatic increase in mission return,
- Many critical operations would benefit from having uninterrupted coverage for several hours,
- Powerful error-correction could be applied when using multiple downlink stations,
- Enables access to a large amount of live spacecraft data at low cost,
- Encourages formation of a coherent space education community.



The Solution:

Develop a flexible global software standard which allows existing educational and radio amateur ground stations worldwide to link together, communicate with each others' satellites, and stream the mission data to the operators via the Internet.

GENSO Objectives

- 1) Unparalleled near-global access to educational and radio amateur spacecraft in orbit,
- 2) Remote access for operators to real-time mission data, even in cases when their local groundstation is experiencing technical difficulties,
 - 1) Scheduling of remote uplink sessions via trusted ground stations,
 - 1) Optional automatic remote control of all participating ground stations,
 - 2) Downlink error-correction by comparing multiple data streams,
 - 3) A global standard for educational ground segment software,
 - 4) Definition of an optional standard solution for educational ground-segment hardware, designed to optimise return from GENSO at minimal cost,
 - 5) Recommendations for future educational space hardware in order to enhance mission return utilising GENSO,
- 1) Close collaboration with the Amateur Radio community to support a common interface for applying for frequency allocation and coordination.

Conceptual Overview

GENSO will consist of three main types of entity:

Ground Station Servers, GSS *Software*

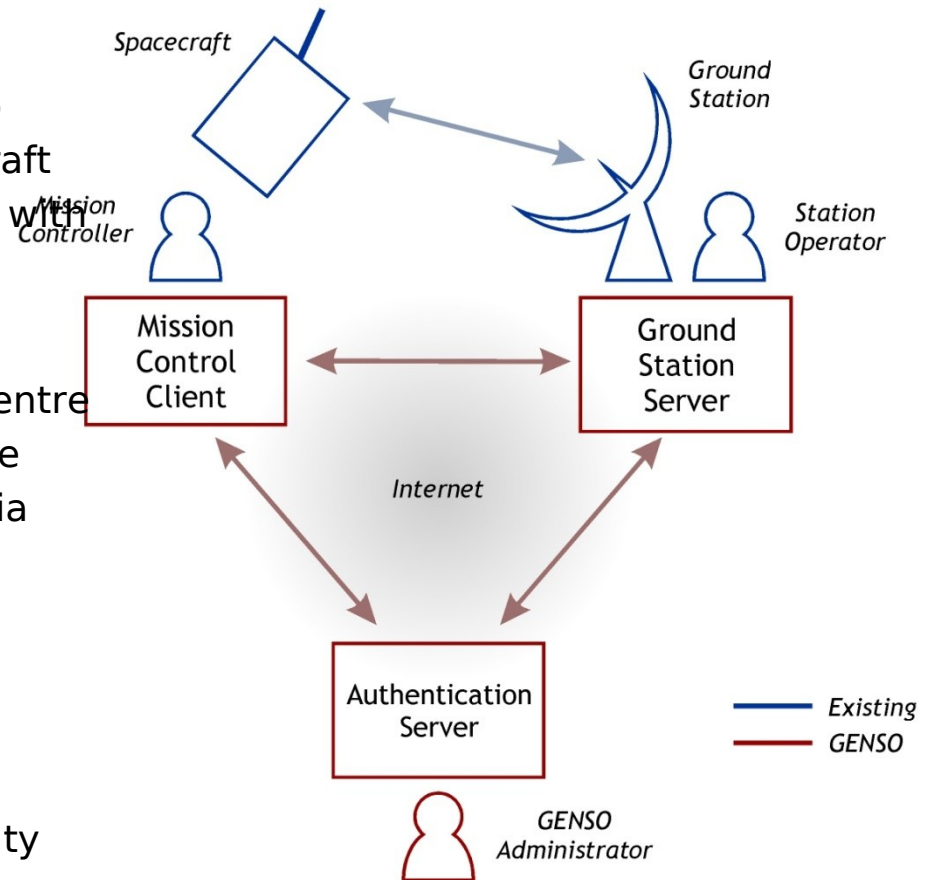
- Running on every GENSO ground station
- Controls the existing local hardware setup
- Communicates with many GENSO spacecraft
- Operated by radio amateurs and students with licences

Mission Control Clients, MCC *Software*

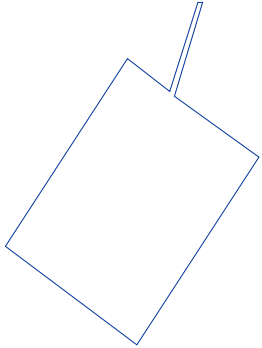
- Running at each GENSO mission control centre
- Interfaces to existing local control software
- Communicates with the local spacecraft via GSSs
- Used by spacecraft controllers

Authentication Servers, ASL *Hardware & Software*

- Monitor and control the network status
- Provide authentication and network security
- A set of mirrored servers, one on each continent
- Controlled by GENSO Administration



GENSO Description (1)

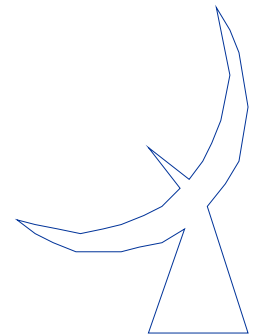


Software Application: *Ground Station Server (GSS)*

The GSS application, when logged on to the Authentication Server, will allow participating GENSO ground stations to automatically track and establish downlink sessions with all compatible participating spacecraft – of course prioritising the owner's craft if they have one. The GSS application will also be used for upload of telecommands to compatible spacecraft (if allowed by the station owner, spacecraft operators and local law). Optional automated scheduling and booking negotiations with the MCC will be able to establish dedicated passes for particular missions. The application will be fully configurable and transparent to the user, and all data will be able to be stored locally as well as transferred to spacecraft operators.

Software Application: *Mission Control Client (MCC)*

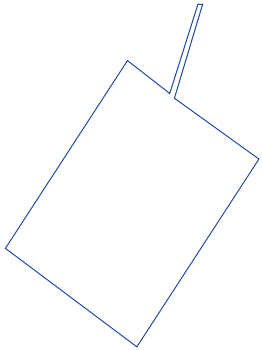
The MCC application, when logged on to the Authentication Server, will allow participating GENSO spacecraft to be automatically tracked by all compatible participating ground stations, from which downloaded data shall transferred to the MCC in real-time (or as bandwidth allows), regardless of the station location. Capable ground stations which operators chose to 'trust' can also be used for uplink to the spacecraft, and users will be able to request dedicated remote passes which the MCC will negotiate and book on their behalf with instances of the GSS. The application will be fully configurable and transparent to the user, and all mission data will be stored locally.



Note: Many more advanced features are also being discussed by the

GENSO Description (2)

Simple Hardware Requirements



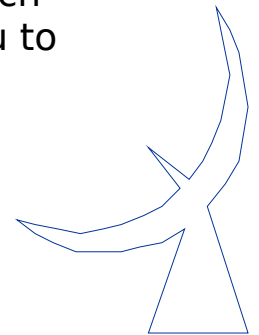
GENSO is being designed to be as flexible as possible with regards to the hardware it can be used with - there are very few inherent restrictions in the system as the design stands today. Of course, we have to start somewhere, and we have chosen to focus primarily on those sections of the VHF, UHF and S bands which are allocated for use by the Radio Amateur community. The GSS shall be released with a large library of device drivers to interface to common radio amateur equipment, but it will also be possible for you to add your own drivers in case some of your hardware is not supported. These could then be included in the library for whole GENSO community.

“Standard GENSO Ground Station”

Although GENSO will be highly flexible, we are working on the definition of an optimum ground station which will serve as a low-cost recommended hardware configuration ensuring an efficient high-return from GENSO utilising one, two, or all three of the main bands. We will build at least two of these stations, one of which will be ESA-ESTEC in the Netherlands. Note that there is no requirement for you to use the same hardware to participate.

The GENSO Community

There is already a great deal of interest in GENSO and we expect it to attract a large number of like-minded people and projects. This community will be a valuable resource, not only for increased access to spacecraft, but also for advice, technical support for ground and space hardware, object identification on busy launches, assistance during critical mission operations, and many other possibilities.



“Standard” Earth Station

- Icom IC-910 radio with computer interface and all the bits
- M² OR2800P-DC for Azimuth and MT-1000 for elevation
- Symek TNC 31S
 - Possibly software in future
- Antennas:
 - 2MCP22 for 145 MHz
 - 436CP42UG for 437 MHz
 - 1 meter dish for S-band (downlink only)
- Computers, LNAs, SWR bridges, PSUs UPS etc etc etc

Project Status

Current

- Preliminary Design Review closed successfully
- Development teams coding and preparing for Alpha Testing as part of the Critical Design Phase
- Two flagship ground stations under procurement (for ESTEC and the International Space University)



- ### Pending
- Over 50 interested educational institutions worldwide via word-of-mouth alone
 - Workshop V scheduled 3-6th November in Aalborg, Denmark
 - Installation of flagship ground station at ESTEC, Netherlands
 - Installation of flagship ground station at ISU, France
 - Alpha Phase to commence soon after Workshop V
 - Inter-Agency Agreement sought to formalise project support and ISEB responsibilities



Example of a university ground station (Luleå)

Project Schedule

<i>12 Oct 2006 – 18 Feb 2007</i>	Kick-off, assignment of work packages
<i>19 Feb 2006 – 21 Feb 2007</i>	Workshop 3, organised by ESA at ESTEC
<i>1 Jan 2007 – 15 June 2007</i>	Design and Development Phase
<i>2 July 2007 – 6 July 2007</i>	Workshop 4, Preliminary Design Review, organised at CalPoly, USA
<i>6 July 2007 – 7 Nov 2007</i>	Preliminary Implementation
<i>8-11 Nov 2007</i>	Workshop 5, Aalborg, “ <i>Alpha Phase</i> ” kick-off
<i>Nov 2007 – Feb 2008</i>	Core Testing and Development, “ <i>Alpha Phase</i> ” (including ~7 stations)
<i>March 2008</i>	Workshop 6, Critical Design Review, “ <i>Beta Phase</i> ” kick-off
<i>March 2008 – July 2008</i>	Advanced Testing and Development, “ <i>Beta Phase</i> ” (including ~20 stations)
<i>July 2008</i>	Workshop 7, Advanced Development
<i>Nov 2008</i>	Workshop 8, System Verification Review
<i>Nov – Feb 2009</i>	Preparation for Network Deployment
<i>March 2009</i>	Workshop 9, Deployment Readiness Review
<i>April 2009</i>	Network Inauguration, deployment, operation and maintenance

Participants:
June 2009 +

Implementation
Enhanced development
teams only

Development
Ground Stations

Open to all
Missions /
Stations

Getting Involved

For the moment:

The selection of Implementation Teams is closed and the work packages, which are necessary to develop the software, hardware and infrastructure, are all assigned. The Implementation teams will design, develop and test their initial solutions until the end of September 2007.

During this time all expressions of interest and support are greatly appreciated. A project website will provide all relevant news on our progress: www.genso.org

Joining as a 'Development Ground Station':

From March 2008 the project should enter a second pilot phase, during which a larger number of ground stations will be used to test the software and infrastructure of the network.

If you would like to be considered for participation in this phase then please contact us in due course, specifying your interest and giving details of your ground station.

Once GENSO is operational:

It is currently envisaged that GENSO will be fully operational as of April 2009 (although, as with all space projects, this deadline may change).

Once the network is operational any educational, or amateur radio, spacecraft and ground stations will be most welcome to participate. There will be some simple user

Project Participants

Currently Operational
Compatible Spacecraft

AO16, AMSAT
AO51, AMSAT
CAN-X, Canada
CUTE-1, Tokyo Institute of
Technology
GO32, AMSAT
Hitsat, Hokkaido Institute of
Technology
International Space Station
LO19, AMSAT
QUAKE-SAT,
Xi-IV, University of Tokyo
Xi-V, University of Tokyo
...plus plenty of upcoming

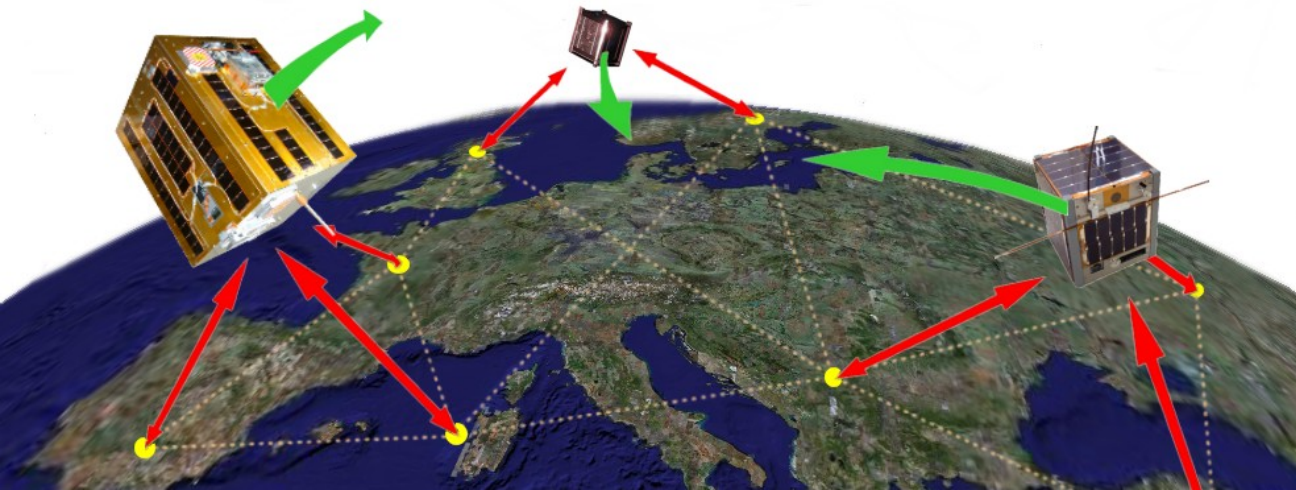
Implementation Teams
& Development Stations

AMSAT-UK, UK
Aalborg University, Denmark
CalPoly, USA
ESA - ESTEC, Netherlands
University Narvik, Norway
Luleå University, Sweden
SSETI Association, France
Surrey University, UK
TU Delft, Netherlands
TU Vienna, Austria
University of Tokyo, Japan
International Space University,
France

Hokkaido Institute of Technology,
Japan
Institute of Space Technology,
Pakistan
Kagawa University, Japan
Kyushu Institute of Technology,
Japan
Kyushu University, Japan
Nihon University, Japan
SOHLA (industrial consortium),
Japan
Soka University, Japan
Stanford University, USA
Sugadaira Space Radio Observatory,
Japan
SvalSat, Svalbard
TU München, Germany
Tohoku University, Japan
Tokyo Institute of Technology, Japan
Tokyo Metropolitan College, Japan
University of Aachen, Germany
University of Bologna
University of Chile, Chile
University of Manitoba, Canada
University of Mauritius, Mauritius
University of Toronto, Canada
University of Patras, Greece
University of Porto, Portugal
University of South Australia,
Australia
University of Stuttgart, Germany
University of Tokyo, Japan

CubeSats

Please Note: This is not an exhaustive list, there has been a large amount of interest expressed.



Contact Us

Given the complex nature of this project, the development of the GENSO systems will take some time. Please bear with us, and we look forward to welcoming you into the network once it is ready.

More information can be found on the project website

www.genso.org

Project Coordinator

Neil Melville, ESA Education Department, neil.melville@esa.int

“GENSO – Creating Clear Horizons”

SSETI-ESEO



15/07/2007

SSETI ESEO - Basic data

Orbit - geo-synchronous transfer orbit

Launch vehicle - Ariane 5 or Soyuz ST

Launch site - Kourou French Guiana

Launch date - 2010?

Apogee - 35900km Perigee - between 250 and 500km

Mean motion - 2.289 orbits per day

Decay period - ???



AMSAT-UK ESEO Project team members:

David Bowman - GOMRF

Jason Flynn - G7OCD

Freddy de Guchteneire ON6UG

Sam Jewell - G4DKK

Howard Long - G6LVB

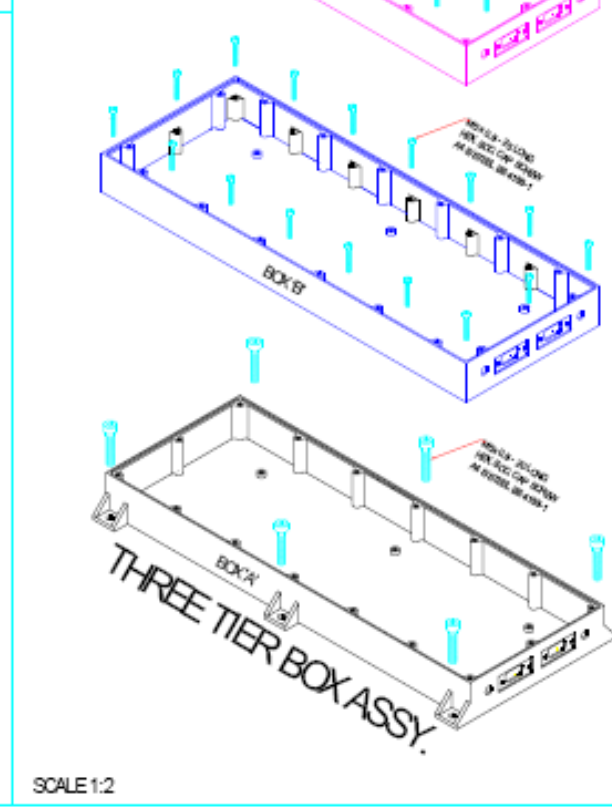
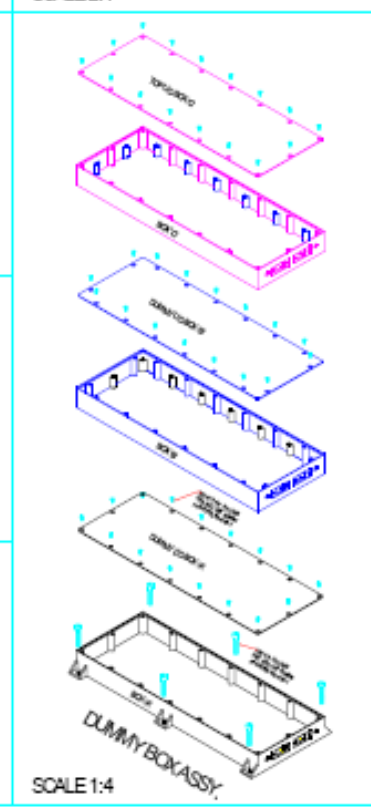
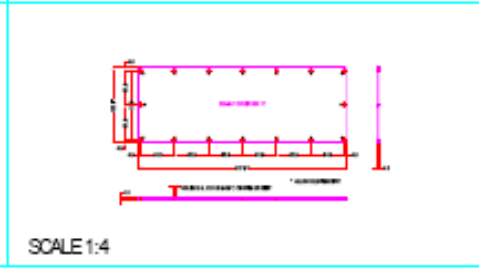
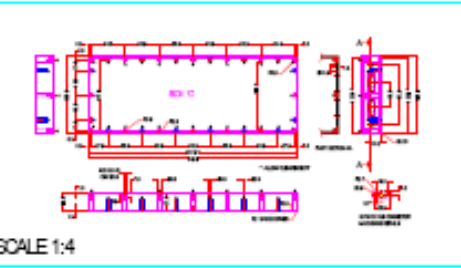
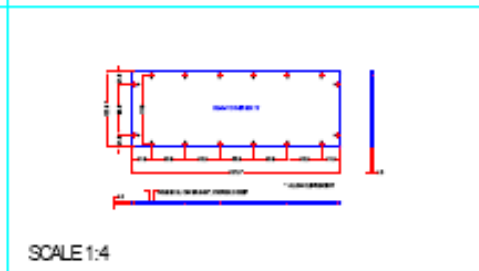
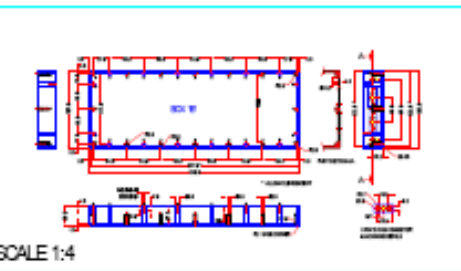
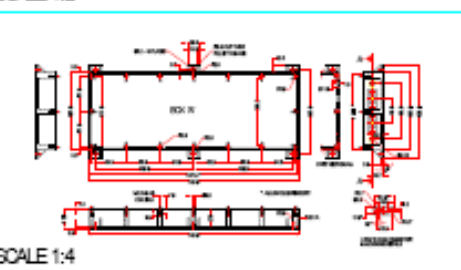
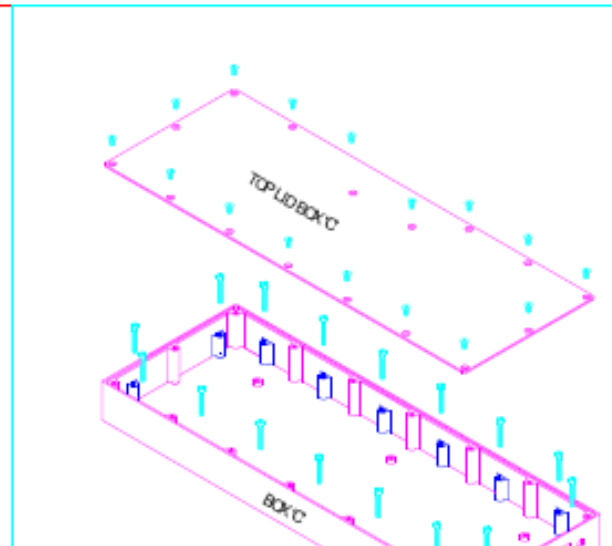
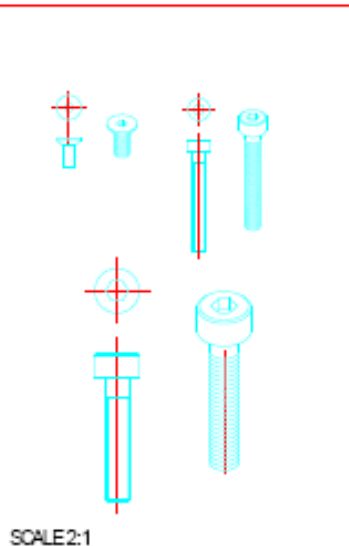
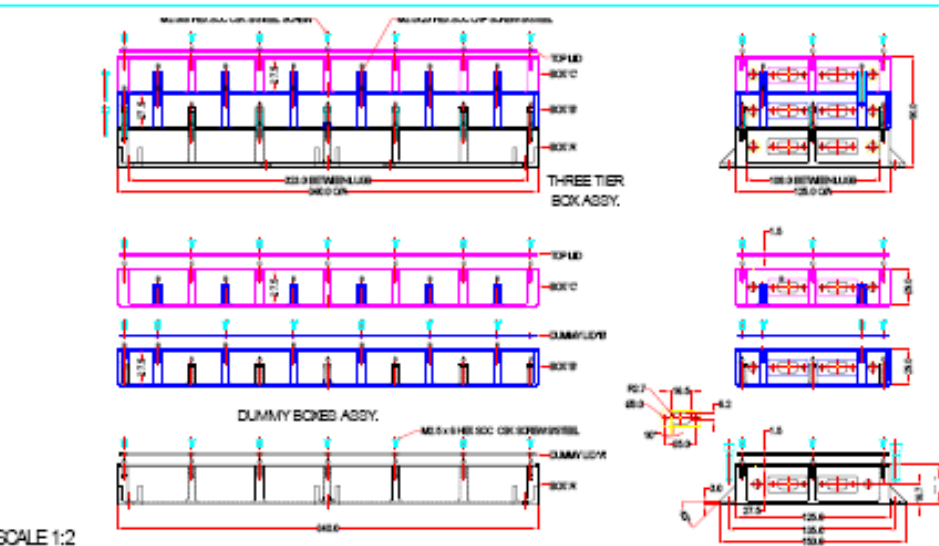
Graham Shirville - G3VZV

Charles Suckling - G3WDG



SSETI -ESEO TC/TM transceiver & Transponder

- **UHF Receiver / antennas**
- **Command decoder / CAN interface to OBDH**
- **Linear transponder and DSP Transponder function**
- **TeleCommand receiver**
- **400bps Telemetry transmitter**
- **S Band High 10 watt Power Amplifier / antennas**
- **AMSAT module control and protection system**

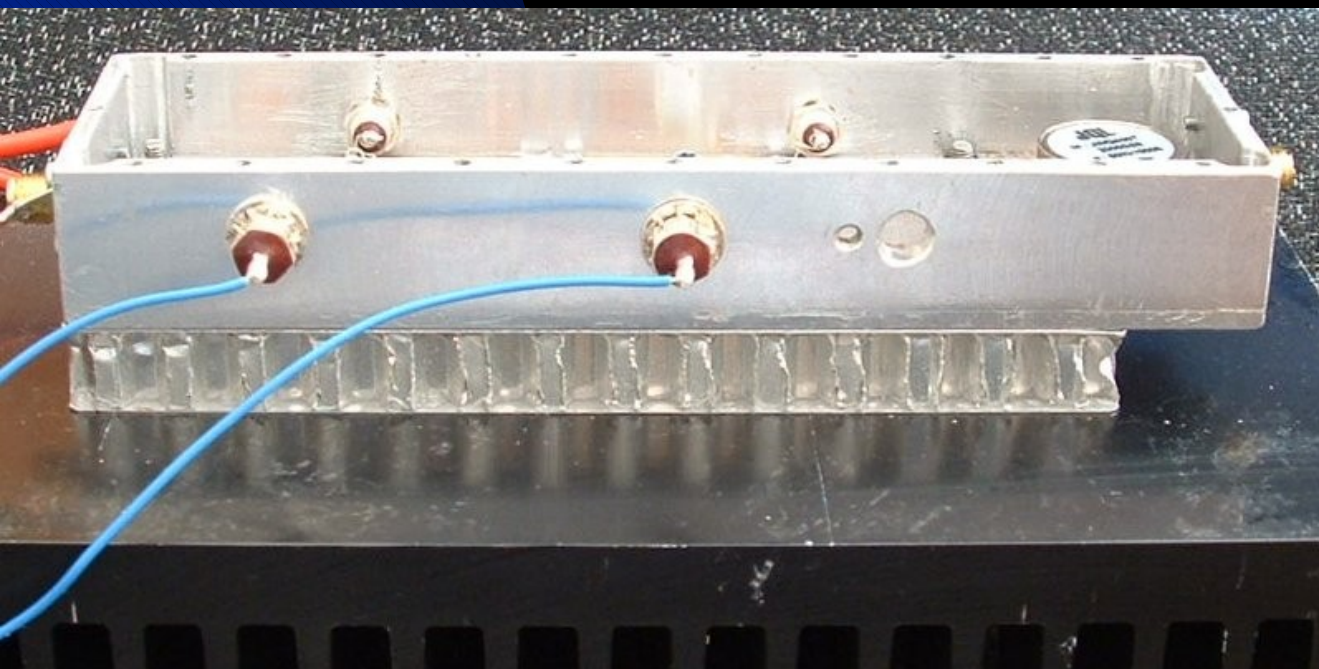
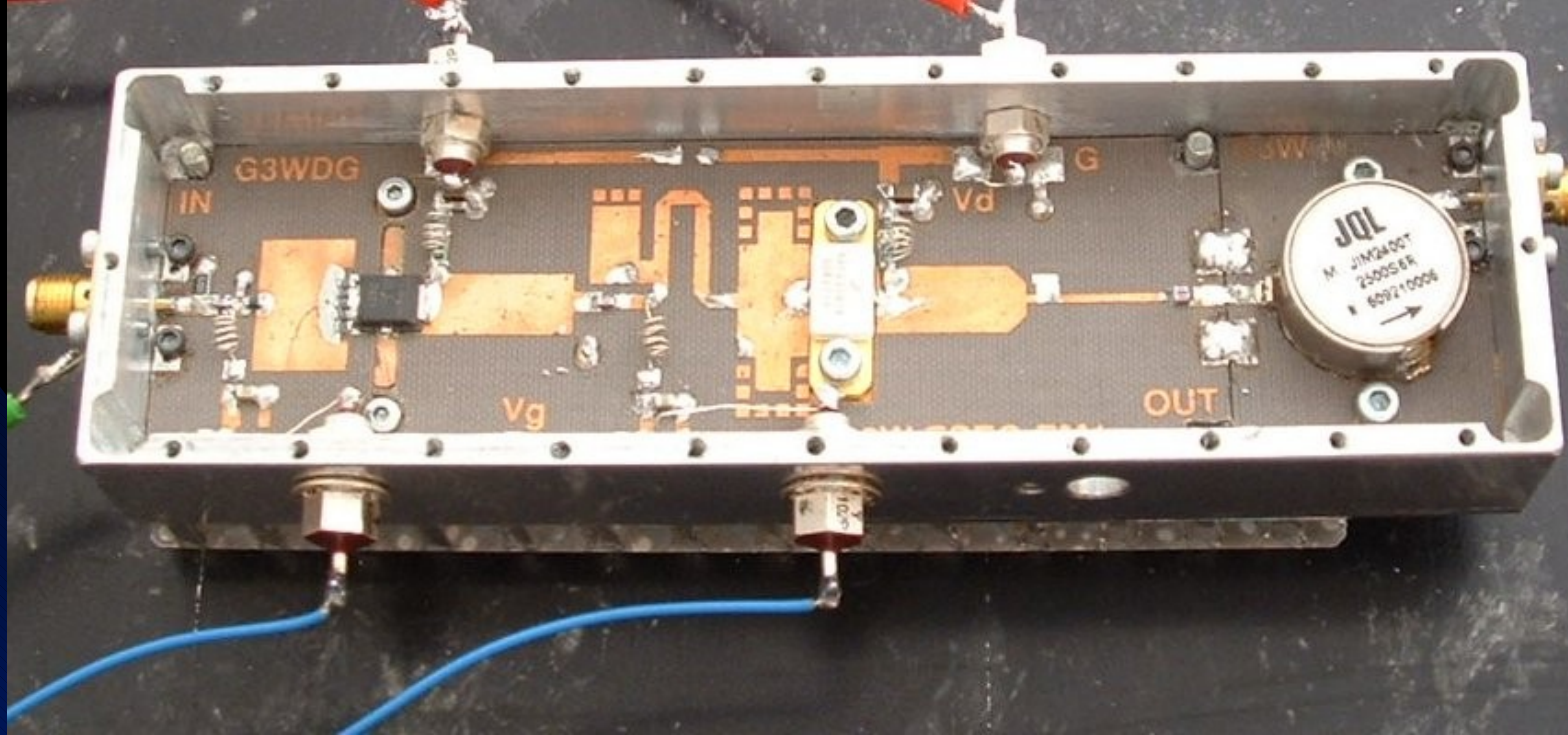


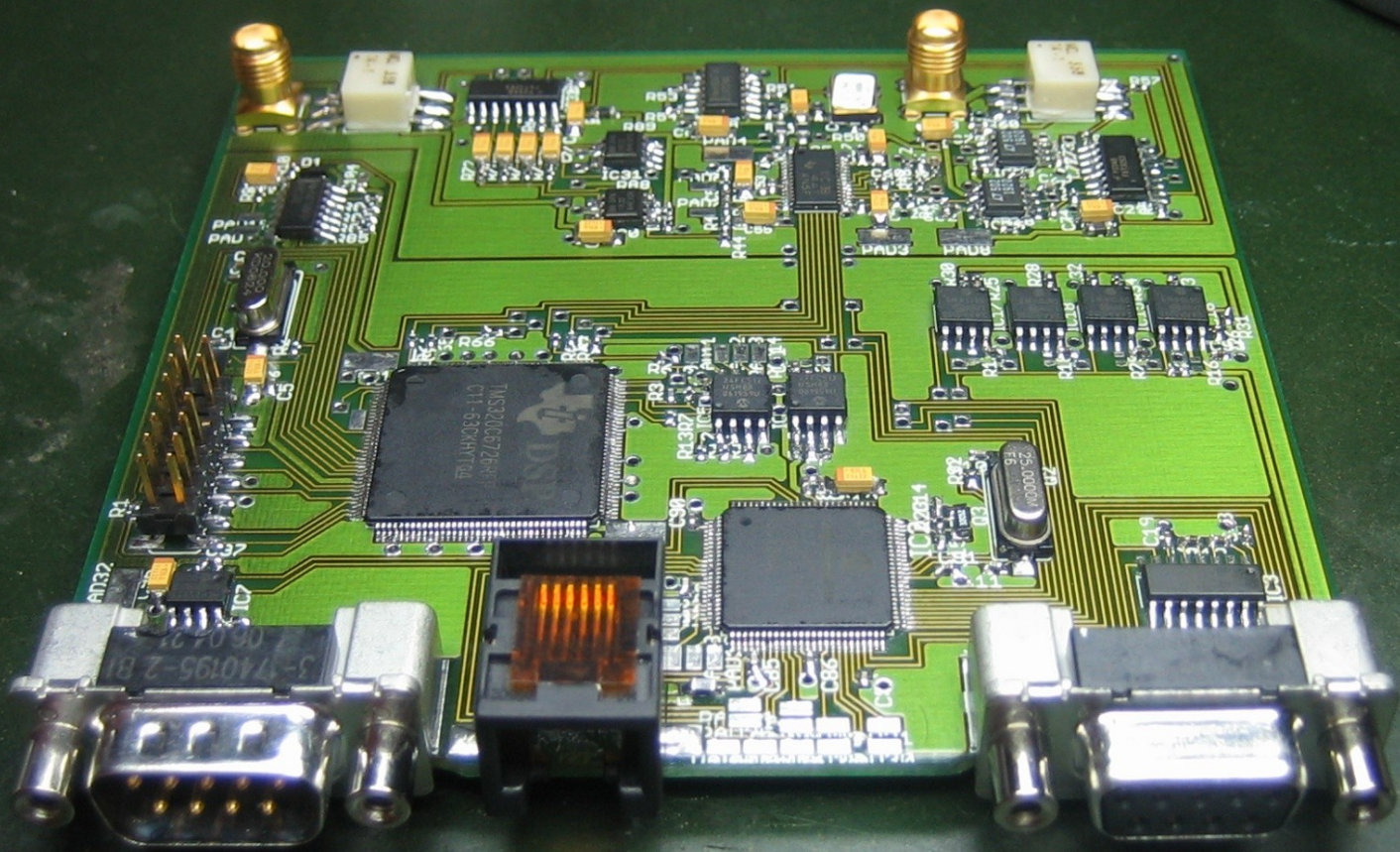
DIA 6.35 HOLES & RECESS ADDED
32x13 RECESS OUTSIDE & BOSSES REMOVED

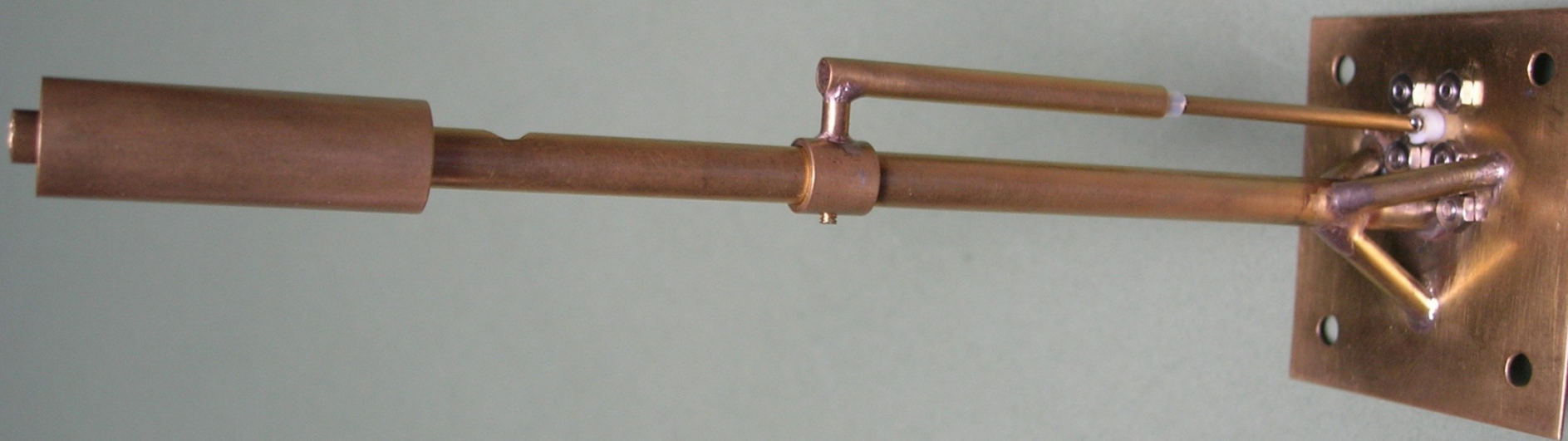
04 30.05.07
05 04.06.07

SSETI BOX

SSETI BOX







31.05.2007

SSETI ESEO Prototype Command Receiver

435 Input from LNA

Mixer / Diplexer

45 MHz amp and crystal filters

391 MHz
VCO

CIO

AGC

Loop filter

TCXO
20 MHz

LMX2306
Data input

Audio
filter

Product detector

PCB 115 x 38mm

SSETI - ESEO Project provisional timetable - as @ October 2007

Phase B: Detailed Definition

Jan 2008 Preliminary Design Review

Phase C: Development

Jan 2009 Critical Design Review

Phase D: Manufacture, Integration & Test

Jan2010 Transport to Kourou

Phase E: Launch

Nov 2010

Phase F: Mission Operation

Nov 2010 until ?



Will use a bi-propellant engine for transition from GTO to lunar orbit perhaps 2011/2012

Will need a V SMALL low power microwave beacon for tracking purposes.....

An Amateur Radio Station on **Columbus** the European Space Laboratory



**The European Space Laboratory
Columbus
will be delivered to the ISS December
2007 on STS**

**Built in Bremen, Germany, the module is
presently at Kennedy Space Center**



Columbus leaves Bremen for KSC, 28 May 2006

Amateur Radio on Columbus

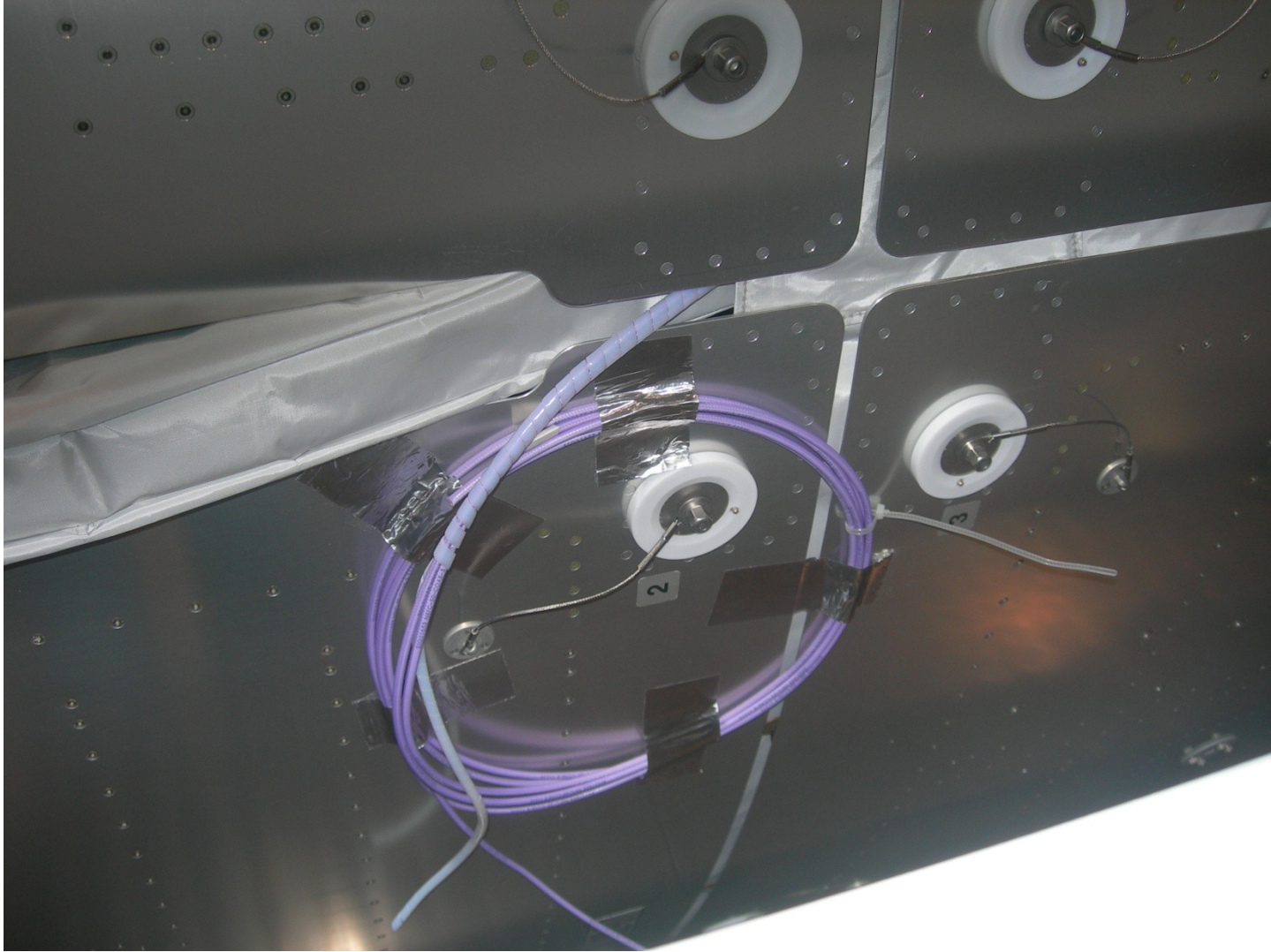
- **ESA has accepted to host an amateur radio station on Columbus Space Laboratory**
- **Project :**
 - **Patch antennas for L/S-bands on the nadir of the module**
 - **Two double band antennas fixed on Meteorite Debris Panels**
 - **Linear transponder -Digital ATV -Educational use**
- **Development:**
 - **Two coaxial cables have been installed**
 - **Four series of antennas built**
 - **Antennas survived 49G vibration tests (shaker at ESTEC broke down...)**
 - **Two antennas installed and tested 6-10th October**
 - **Columbus hatch shut for last time 16th October!**

Amateur Radio on Columbus



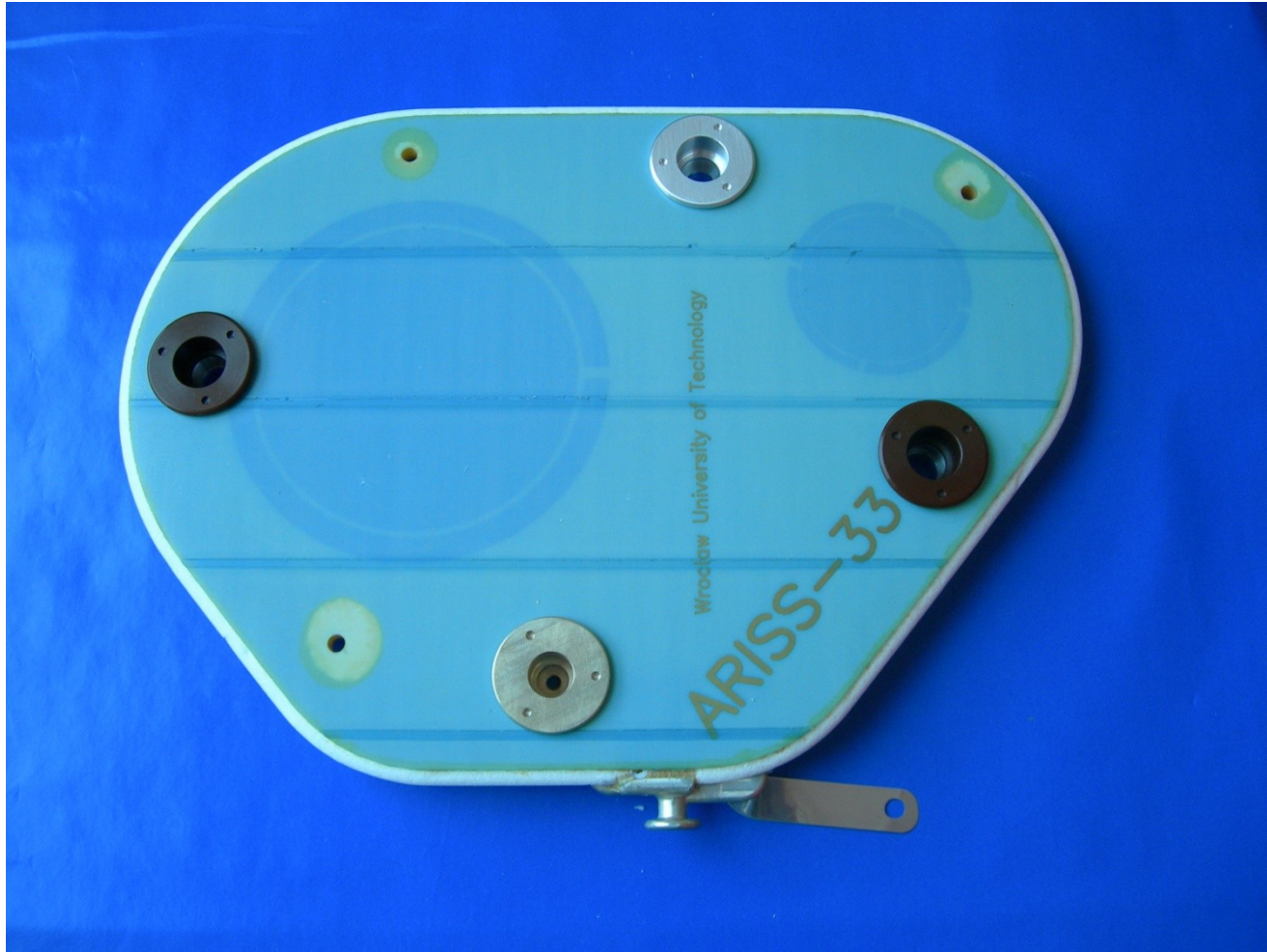
**Technicians installing ARISS coaxial cables at
EADS, Bremen**

Amateur Radio on Columbus



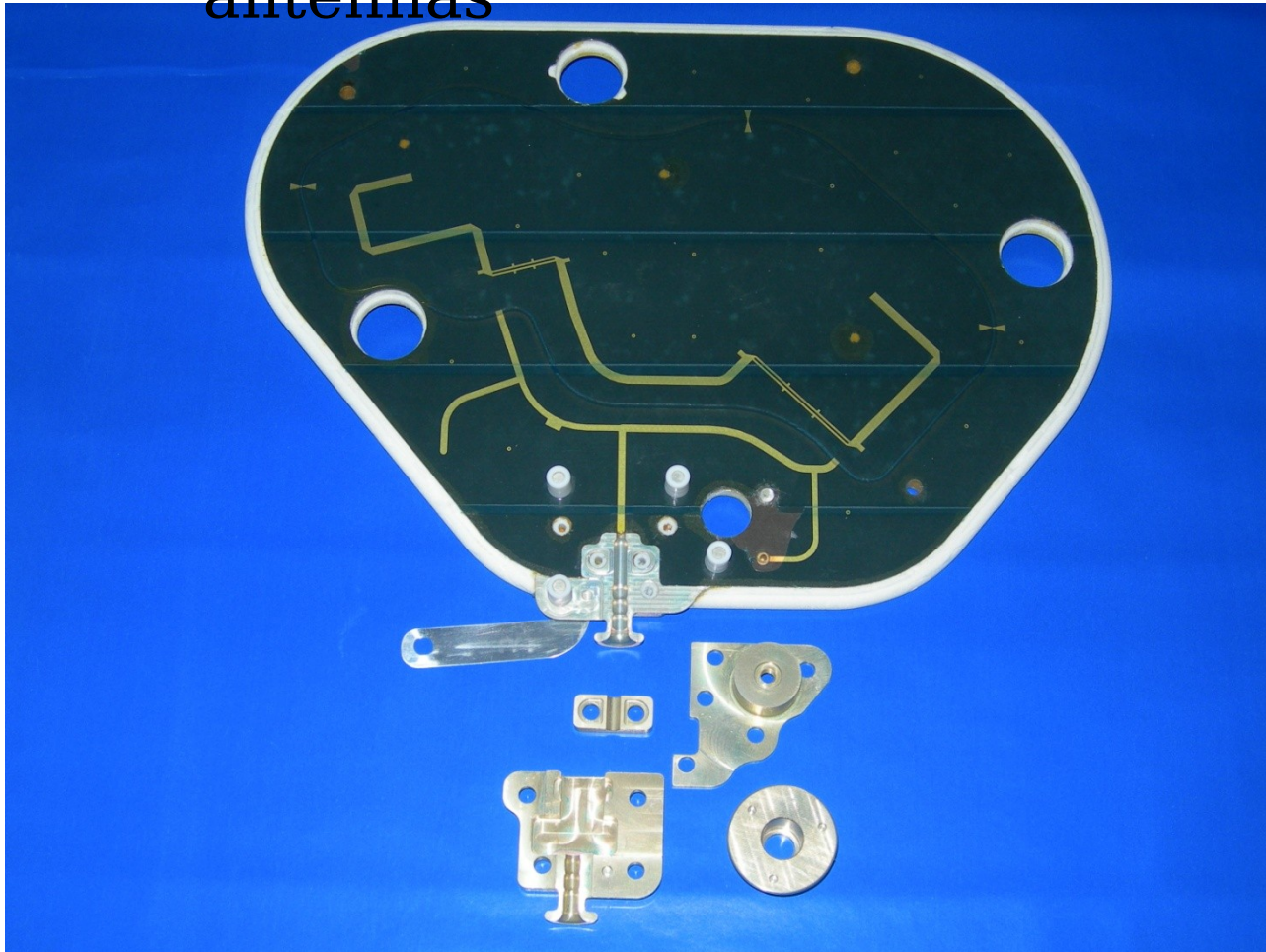
The installed coax cables as delivered to Kennedy

ARISS L/S-band patch antennas



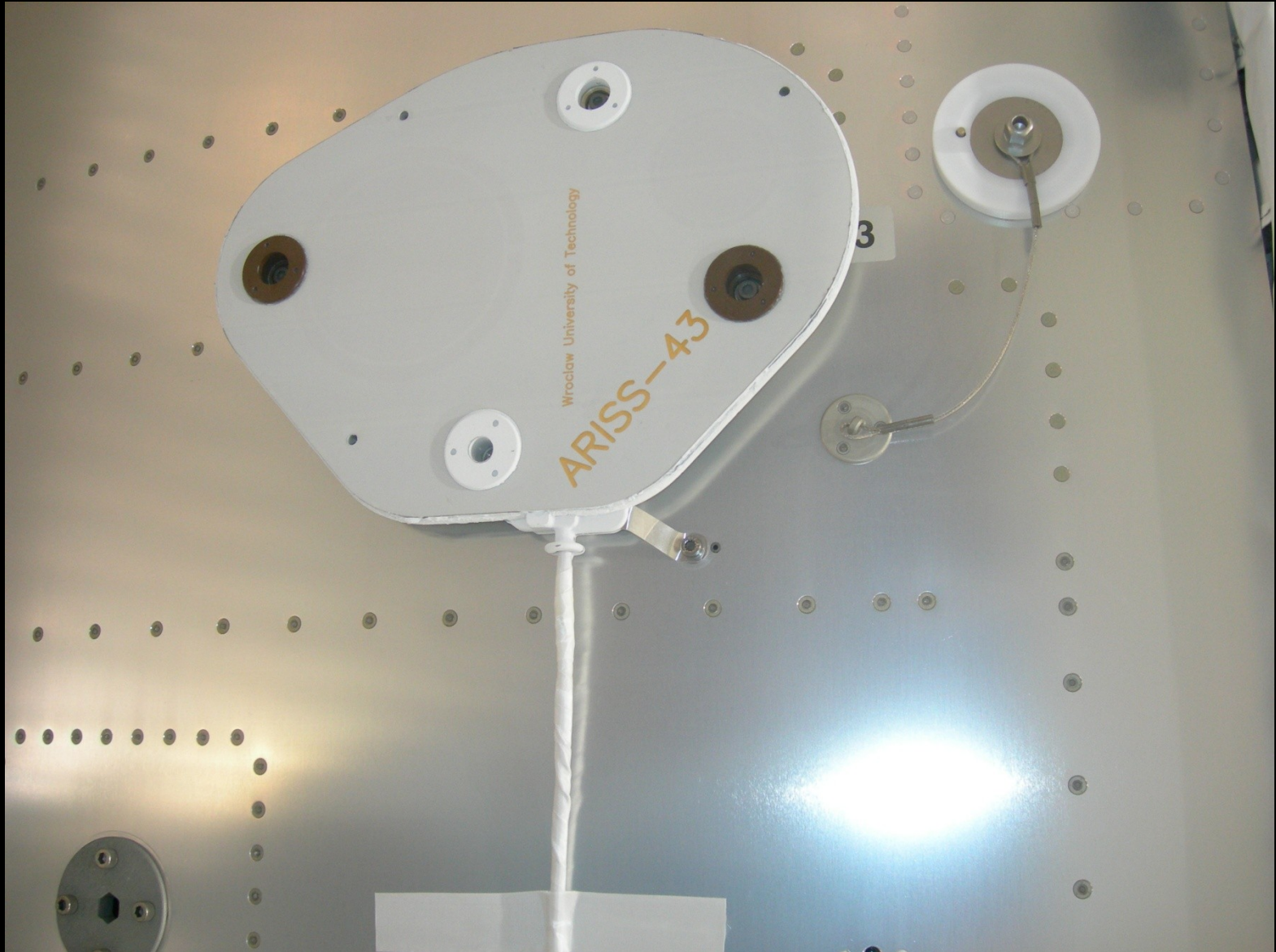
Front

ARISS L/S-band patch antennas



Rear





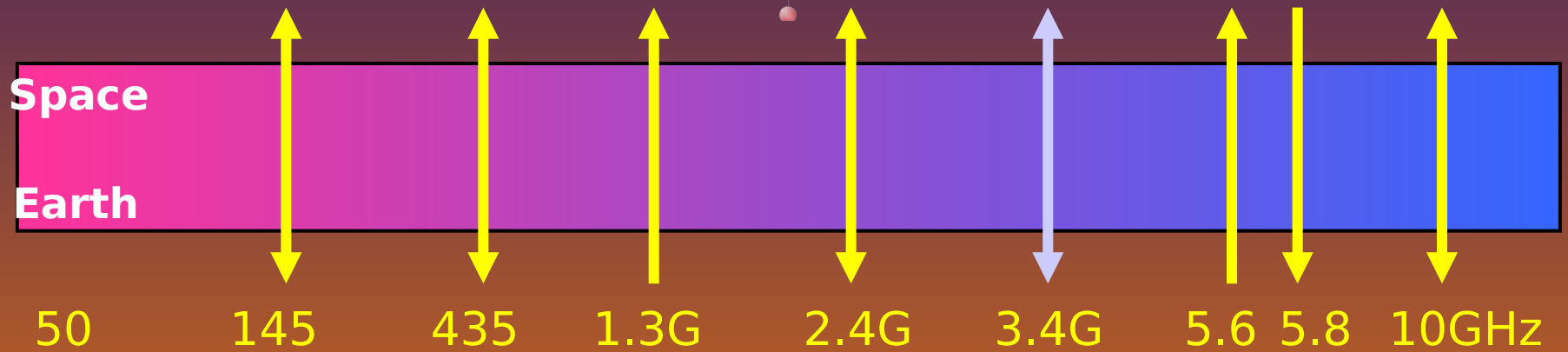
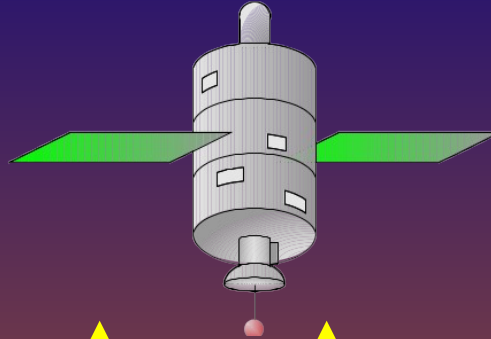
Funding campaign continues

- **Antenna installation costs \$210,000+ funded by ESA**
- **ARISS has paid \$110,000 for antenna development and manufacture**
- **Wroclaw University of Technology estimates the cost about \$440,000, covered by ARISS and Polish subsidies**
- **Certification tests cost \$21,000 funded by ESA**
- **Equipment has to be developed and built**
- **More funding is needed**
- **Donations can be made by PayPal at**
<http://www.ariss-eu.org/columbus.htm>



The Future of the Amateur Satellite Service Spectrum

VHF/Microwave Allocations



* Region-2/3 Only – not used so far

Only 145 is Primary.

Key: S-E ↓ E-S ↑ Both ↔

Amateur Satellite Service

- **RR1.56 Amateur Service:**
A radiocommunication service for the purpose of selftraining, intercommunication and technical investigations carried out by amateurs, that is, by duly authorized persons interested in radio technique solely with a personal aim and without pecuniary interest.
- **RR1.57 Amateur-Satellite Service:**
A radiocommunication service using space stations on earth satellites for the same purposes as those of the amateur service

Key Satellite Regs

- **RR5.282**

In the bands 435-438MHz, 1260-1270MHz, 2400-2450MHz, 3400-3410MHz (in Regions 2 and 3 only) and 5650-5670 MHz, the amateur-satellite service may operate **subject to not causing harmful interference** to other services

- Administrations authorizing such use shall ensure that any **harmful interference** caused by emissions from a station in the amateur-satellite service is immediately eliminated in accordance with the provisions of **No. 25.11**.
- The use of the bands 1260-1270 MHz and 5650-5670 MHz by the amateur-satellite service is limited to the Earth-to-space direction.

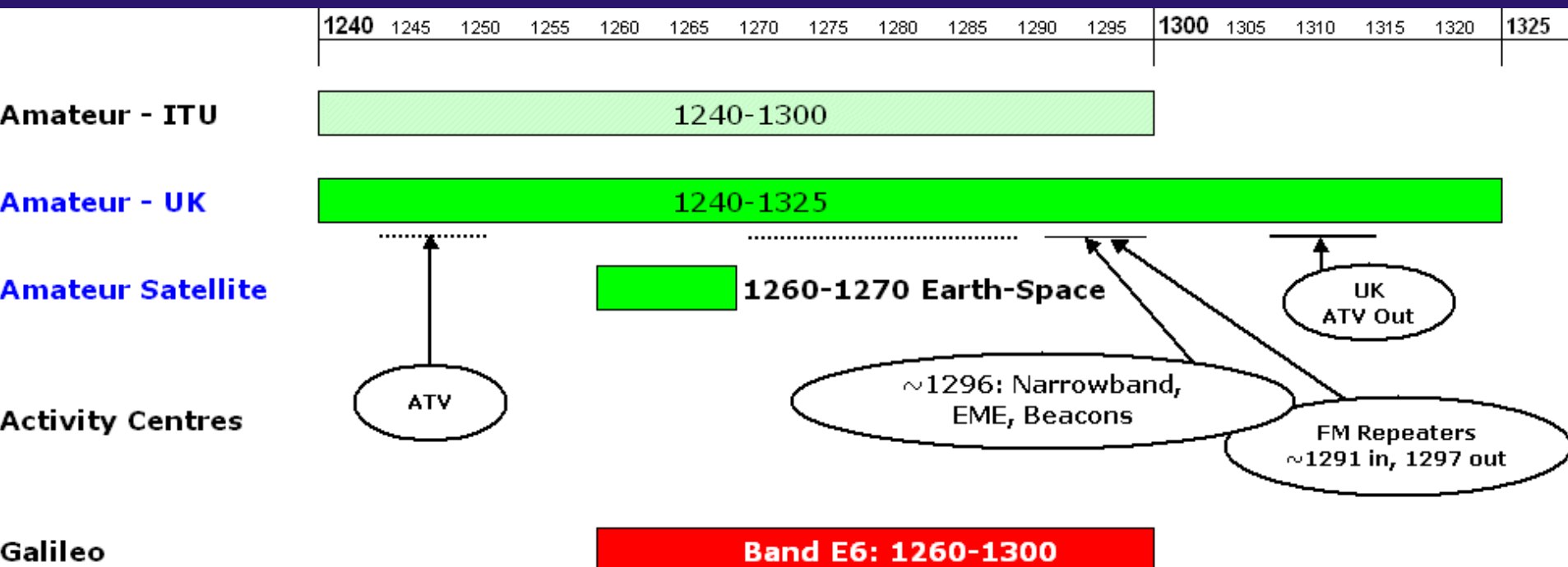
More Regs

- **22.1** Space stations shall be fitted with devices to ensure immediate cessation of their radio emissions by telecommand, whenever such cessation is required under the provisions of these Regulations.
- **25.11** Administrations authorizing space stations in the amateur-satellite service shall ensure that sufficient earth command stations are established before launch to ensure that any harmful interference caused by emissions from a station in the amateur-satellite service can be terminated immediately (see No. 22.1). (WRC-03)
- **BUT WOULD FLYING A 50MHz SURVEY RECEIVER OR NATIONAL UPLINKS BE A REAL BREACH ? – NO HARMFUL INTERFERENCE... *cf. downlinks***

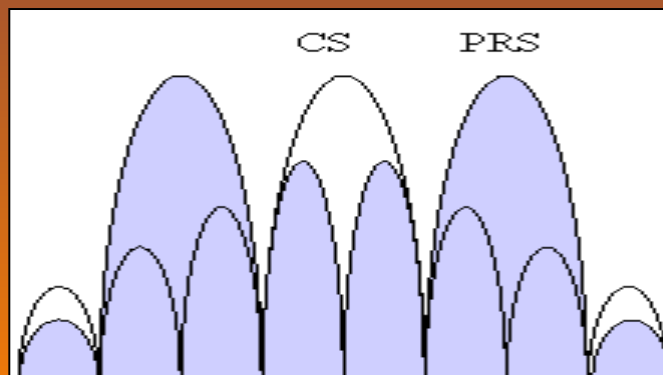
Threat Review

- See 2005 Amsat-UK Colloquium Proceedings
- Some are our own fault:
 - Most allocations are smaller than terrestrial ones nor well aligned
- So just a few examples now...

23cms & Galileo



Galileo E6 Services:
CS: Commercial Service
PRS: Public Regulated Service



**1278.75MHz centre
 +/- 20 x 1.023MHz**

A 23cms Study

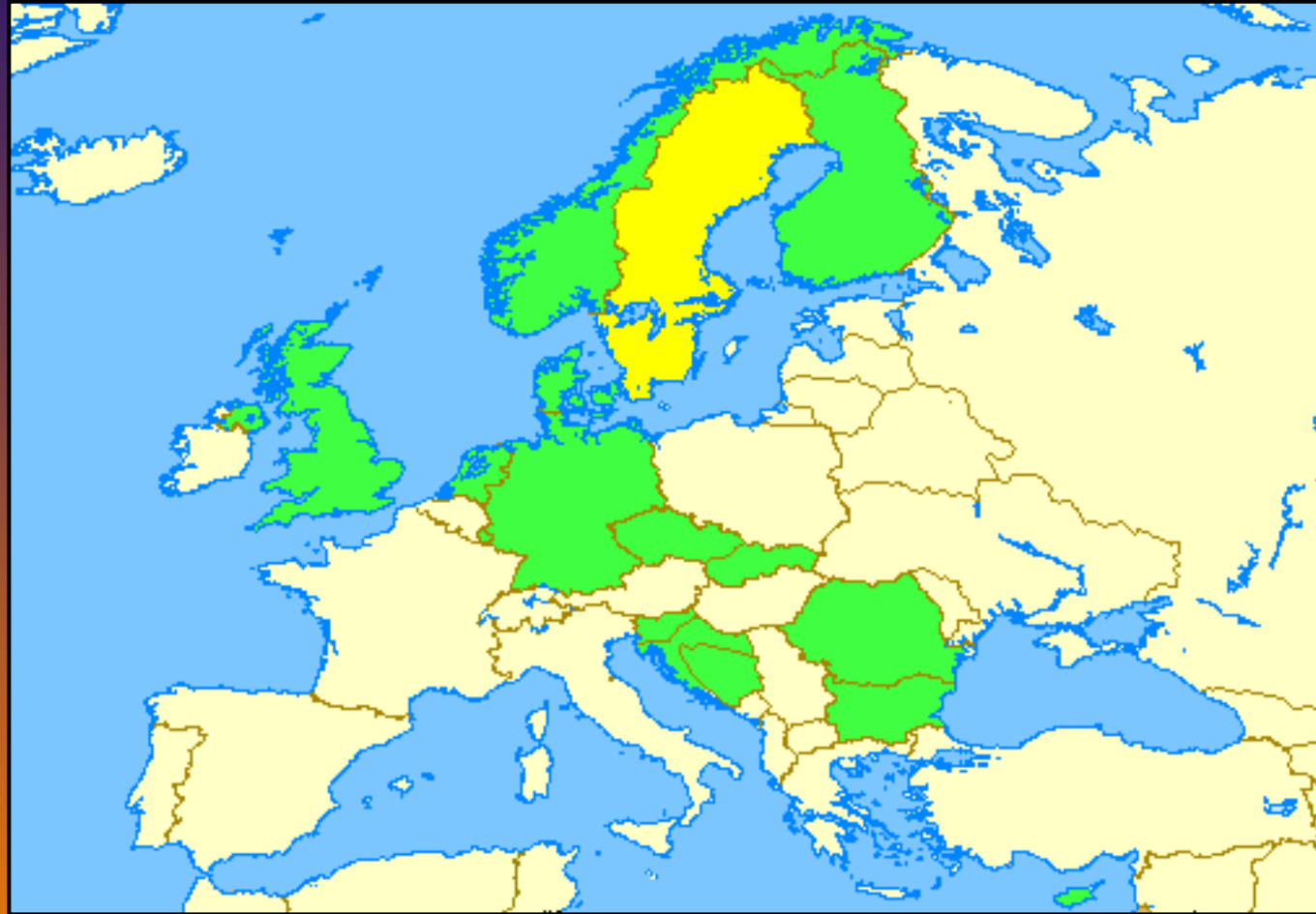
- In the UK 1260-1270 has ATC radar and other PU systems
- New 2500-2690 MHz 3/4G must not get harmonic interference
- Concerns over Galileo in 1260+
 - more likely to happen if Publicly funded by EU
- RSGB Vienna Paper B15 has actioned a review of fallback plans to be discussed at IARU-R1 Cavtat 2008 conference based on a new 10MHz band – 1240/50, 1260/70 or 1290/1300 MHz

3.4GHz Amateur Allocations

- In Region-1 the low allocation level and lack of formal ITU allocation can severely undermine use in Region-2/3
- WRC-07 AI 1.4 likely to see 3400-3600 being designated for IMT-Advanced (aka 4G)
- 3.4-3.6 Already allocated for FWA and is an EU Common Position for IMT

3.4GHz in Europe

- Most are 3400-3410MHz
- Only UK & Germany had more
- Key for P3 and P4 projects & escaping 2.4G QRM



3.4GHz and WRC-07

- 3.4GHz could be 'designated' for IMT-Advanced and 'lost'
- RSGB Position on WRC-07 AI 1.4:
- *Any position that is adopted should account for incumbent users spectrum requirements. In this regard we highlight the Spectrum Requirement to extend the 3400-3410MHz Amateur Satellite Service allocation to ITU Region-1, harmonising all three ITU regions.*
- *If both the Amateur and Amateur Satellite Services were given globally harmonised protected allocations in this lower 10MHz range we would be prepared to consider greater sharing in the spectrum above 3410.*
- **ie We should trade wider allocations to unify 3400-3410 before its too late**

Spectrum Defence

- Do we deserve to keep allocations if we don't use them...?
- We need a concept of 'BeaconSats'
- Use full size Sats or Cubesats to fly a simple beacon on every band
- Put new Terrestrial Beacons on Sat Freqs
- Benefits Spectrum issues, Propagation, spurs wider variety of Tx and Rx designs

Opportunities

- Don't accept it takes 15 years of WRCs to get an allocation!
- Work more closely between Amsats and with NatSocs & IARU
- IARU Only has observer status at WRCs
- Can we get some quick wins...?
- Can we achieve
'common narrowband segments'

The Case for 50MHz

- No allocation between 30MHz and 144MHz
- Antennas Still Practical compared to HF
- Fewer commercial users.
 - Potential for exclusive use in 50-51MHz
- Low Doppler
- Scope for Innovative Propagation Research
- 6m Band likely to be a WRC-11 IARU target
- BUT Satellites NOT in IARU Requirement at <http://www.iaru.org/ac-spec06.html>

Design for The Future

- Designs needed for
- Beacons
- Frequency agility in longer lived designs to permit allocation changes
- Fly 'Survey receivers'
- Acquire Uplink Rights
- Exploit DDS Synthesisers and SDR more

EU Alignment Issues

- **EU17:** In the sub-bands 3400-3410MHz, 5660-5670MHz, 10.36-10.37GHz, 10.45-10.46GHz the amateur service operates on a secondary basis. In making assignments to other services, CEPT administrations are requested wherever possible to maintain these sub-bands in such a way as to facilitate the reception of amateur emissions with minimal power flux densities.
- **EU23:** In the sub-bands 5660-5670MHz (earth to space), 5830-5850MHz (space to earth) and 10.45-10.50GHz the amateur-satellite service additionally operates on a secondary and non-interference basis to other services. In making assignments to other services, CEPT administrations are requested wherever possible to maintain these allocations in such a way as to facilitate the reception of amateur emissions with minimal power flux densities.

Frequency Change Proposals

Band	Requirement/Action	Priority
50-51MHz	Seek new harmonised Amateur Satellite Service E-S/S-E allocation for communications and propagation research to complement existing Amateur Service requirements.	1B
438-440MHz	Extension to existing allocation – E-S & S-E	2A
1240-1250MHz	E-S & S-E - trade for relinquishing existing 1260-1270*, coordinated with existing Amateur Service requirements/priorities	1B
2300-2330MHz	E-S & S-E - trade for relinquishing existing 2400-2450MHz - reduce mutual problems with other services	3A
2390-2400MHz	E-S & S-E - trade for relinquishing existing Amateur Satellite Service allocation at 2400-2450MHz - reduce problems with other services NB1: The Amateur Service is already Primary in USA 2390-2395MHz and shared Primary 2395-2400MHz NB2: Retaining 2400-2450 for the Amateur Service is still believed to be beneficial at this time despite increasing ISM interference issues	1A
3400-3410MHz	E-S & S-E - trade for relinquishing all 3410-3500MHz and seek protection from WRC-07/11 IMT/BWA Comms services Already available in ITU Regions 2&3 – The lack of a Region-1 allocation inhibits use	1A
5650-5670MHz	E-S & S-E -upgrade from E-S only - trade for reducing width of current 5830-5850 allocation	3A
10GHz	The satellite service requires 10MHz of Primary allocation..... Consider a move/extension towards the 10360-10400 area in exchange for relinquishing 10460-10500 Press for 10450-10460 to be upgraded to Primary	3B

Common Segments ?

Current UK Terrestrial Allocations				Possible Future Allocations			
Fstart	Fstop	BW, MHz			Fstart	Fstop	BW, MHz
1240	1325	85			1240	1250	10
2310	2400	90			2310	2330	20
2400	2450	50			2390	2400	10
3400	3475	75			3400	3420	20
5650	5680	30			5650	5670	20
5755	5765	10			5755	5765	10
5820	5850	30			?	?	0
10000	10125	125			?	?	0
10225	10475	250			10360	10460	100
24000	24050	50			24000	24050	50
24050	24150	100			trade-in		
24150	24250	100			trade-in		
Total		995					240

- Important to harmonise with Narrowband, Amsat & EME – Worldwide DX
- Preserve enough for ATV
- A Long term plan – that starts now!

144MHz at IARU Meeting in Vienna

- Proposal to enable more spectrum for satellite operations around 144.35 MHz
- **New Opportunity:-**
Old 144.000/035 EME Allocation is globally harmonised but largely neglected since 144.100+ now in greater use
- **Action point for the Satellite Coordinator G3VZV:** To review Vienna discussions, to analyse information from the other regions, and to consider submitting a further paper at the 2008 follow-up conference, including full justification for the need to act.

Summary

- Future could be bright and exciting if Amsat(s) convince IARU Member Societies to back them
- Its up to you.....!